Claims

1. A method of coating a substrate comprising the steps of:

a) providing at least a first population of particles and a second population of particles to be sprayed;

b) providing a supersonic nozzle having a throat located between a converging region and a diverging region, directing a flow of a gas through the nozzle, maintaining the gas at a selected temperature, and injecting the first and second populations of particles into the nozzle at the same time and entraining the first and second populations of particles in the flow of the gas;

c) the temperature of the gas selected to be insufficient to heat the first population of particles to a temperature at or above their melting temperature in the nozzle and accelerating the particles to a velocity sufficient to result in adherence of the particles on a substrate positioned opposite the nozzle, and the temperature of the gas selected to be sufficient to heat the second population of particles to a temperature at or above their melting temperature in the nozzle thereby melting the second population of particles and accelerating the molten particles to a velocity sufficient to result in adherence of the particles on the substrate; thereby forming a coating on the substrate that is a combination of the first and second populations of particles.

2. The method of claim 1, wherein step a) comprises providing first and second populations of particles each having an average nominal diameter of from 50 to 250 microns.

3. The method of claim 1, wherein step a) comprises providing first and second populations of particles each having an average nominal diameter of from 106 to 250 microns.

4. The method of claim 1, wherein step a) comprises providing at least a first and a second population of particles that differ from each other in at least one of size, shape, or material composition.

5. The method of claim 1, wherein step b) comprises providing air, argon, nitrogen, or helium as the gas.

6. The method of claim 1, wherein step b) comprises maintaining the main gas at a temperature of from 300 degrees Celsius to a temperature that is seven fold above the highest melting temperature of the first and second populations of particles.

7. The method of claim 1, wherein step b) comprises injecting at least one of the first and the second populations of particles into the converging region of the nozzle prior to the throat.

8. The method of claim 1, wherein step b) comprises injecting at least one of the first and the second populations of particles directly into the diverging region of the nozzle after the throat.

9. The method of claim 1, wherein step c) comprises accelerating the first and second populations of particles to a velocity of from 300 to 1500 meters per second.

10. The method of claim 1, wherein step c) comprises heating the second population of particles to a temperature of from their melting temperature to a temperature 400 degrees Celsius above their melting temperature.

11. The method of claim 1, wherein step c) comprises heating the second population of particles to a temperature of from their melting temperature to a temperature 200 degrees Celsius above their melting temperature.

12. The method of claim 1, wherein step c) comprises heating the second population of particles to a temperature of from their melting temperature to a temperature 100 degrees Celsius above their melting temperature.

13. The method of claim 1, wherein step c) comprises positioning a substrate comprising a metal, an alloy, a ceramic, a plastic, a semi-conductor, wood, paper, or mixtures thereof opposite the nozzle.

14. The method of claim 1, wherein step a) comprises providing first and second populations of particles comprising a metal, an alloy, a ceramic, a polymer, or mixtures of thereof.

15. The method of claim 1, wherein step b) comprises injecting the first and second populations of particles each through a tube having an inner diameter of from 0.4 to 3.0 millimeters in diameter.

16. The method of claim 1, wherein step b) comprises providing a nozzle having a diverging region with a length of from 60.0 to 400.0 millimeters in length.

17. The method of claim 1, wherein step b) comprises providing a nozzle having a throat with a diameter of from 1.5 to 3.5 millimeters.

18. The method of claim 1, wherein step a) comprises providing a mixture of the first and the second population of particles.

19. A coating on a substrate produced according to the method of claim 1.